

Large HVAC Energy Impact Report

Statewide Energy Impact Report (product 3.4.1)

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PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

This document is one of 33 technical attachments to the final report of a larger research effort called *Integrated Energy Systems: Productivity and Building Science Program* (Program) as part of the PIER Program funded by the California Energy Commission (Commission) and managed by the New Buildings Institute.

As the name suggests, it is not individual building components, equipment, or materials that optimize energy efficiency. Instead, energy efficiency is improved through the integrated design, construction, and operation of building systems. The *Integrated Energy Systems: Productivity and Building Science Program* research addressed six areas:

- Productivity and Interior Environments
- Integrated Design of Large Commercial HVAC Systems
- Integrated Design of Small Commercial HVAC Systems
- Integrated Design of Commercial Building Ceiling Systems
- Integrated Design of Residential Ducting & Air Flow Systems
- Outdoor Lighting Baseline Assessment

The Program's final report (Commission publication #P500-03-082) and its attachments are intended to provide a complete record of the objectives, methods, findings and accomplishments of the *Integrated Energy Systems: Productivity and Building Science Program*. The final report and attachments are highly applicable to architects, designers, contractors, building owners and operators, manufacturers, researchers, and the energy efficiency community.

This attachment, "Large HVAC Energy Impact Report"(Attachment A-22), provides supplemental information to the program's final report within the **Integrated Design of Large Commercial HVAC Systems** research area. The report provides an estimate of the statewide energy savings corresponding to measures recommended in the *Advanced VAV Design Guidelines* developed as part of this research project.

The Buildings Program Area within the Public Interest Energy Research (PIER) Program produced these documents as part of a multi-project programmatic contract (#400-99-413). The Buildings Program includes new and existing buildings in both the residential and the non-residential sectors. The program seeks to decrease building energy use through research that will develop or improve energy efficient technologies, strategies, tools, and building performance evaluation methods.

For other reports produced within this contract or to obtain more information on the PIER Program, please visit www.energy.ca.gov/pier/buildings or contact the Commission's Publications Unit at 916-654-5200. All reports, guidelines and attachments are also publicly available at www.newbuildings.org/pier.

ABSTRACT

The “Large HVAC Energy Impact Report” was produced as a part of the Integrated Design of Large Commercial HVAC Systems research project, one of six research elements of the *Integrated Energy Systems: Productivity and Building Science* Program. This program was funded by the California Energy Commission’s Public Interest Energy Research (PIER) Program.

This project focused on identifying problems and solutions related to the performance of VAV reheat systems in large commercial buildings. The project resulted in the publication of the *Advanced VAV System Design Guide*. The “Large HVAC Energy Impact Report” provides energy-savings projections if buildings were to adopt the Design Guide’s recommendations. The report estimates that:

- For buildings adopting the Design Guide, HVAC electricity savings are estimated to be 25%, corresponding to 12% of total building electricity consumption. Total building natural gas heating savings are estimated to be 41%.
- The Design Guide will apply to roughly 150 million square feet of new buildings built in California in the ten-year period between 2003 and 2012.
- If the best practices recommended in this study were implemented, statewide electricity savings in California are estimated to be 2,220 MWh/yr for new construction. Savings would reach 22,200 MWh/yr at the end of 10 years, and the cumulative electricity savings over that time would be 122,100 MWh.

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Element 3: Integrated Design of Large Commercial HVAC Systems

Erik Kolderup and John Arent, Eley Associates



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ABOUT PIER

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission, annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with research, development and demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

1. Buildings End-use Energy Efficiency
2. Industrial/Agricultural/Water End-use Energy Efficiency
3. Renewable Energy
4. Environmentally Preferred Advanced Generation
5. Energy-Related Environmental Research
6. Strategic Energy Research.

This project contributes to #1 above, the PIER Buildings Program Area. For more information on the PIER Program, please visit the Commission's Web site at: www.energy.ca.gov/research/index.html or contact the Commission's Publications Unit at 916-654-5200. For other public reports within the *Integrated Energy Systems — Productivity and Building Science* project, please visit www.newbuildings.org/pier

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SUMMARY

This report provides an estimate of the energy savings corresponding to publication of the Advanced VAV Design Guidelines developed as part of Element 3 research.

By implementing the “Best Practice” guidelines recommended in this study, statewide electricity savings are estimated to be 2,220 MWh/yr for new construction. Savings would reach 22,200 MWh/yr at the end of 10 years, and the cumulative electricity savings over that time would be 1,221,000 MWh.

The savings are based on an assumed 10% market penetration of large office buildings constructed with applicable VAV reheat systems. This equates to a 5% market penetration of total new large office construction.

For buildings adopting the guidelines, HVAC electricity savings are estimated to be 25%, corresponding to 12% of total building electricity consumption. Natural gas heating savings are estimated to be 41%. Negligible electric demand savings are expected from implementing the guidelines.

ENERGY SAVINGS (PER FT²)

Table 1 shows the electricity savings estimate per square foot of floor area for a building design employing the best practices recommended in the guideline. Table 2 shows the savings for natural gas. Baseline energy consumption is taken from PG&E’s 1999 Commercial Building Survey for the office building category (which matches reasonably well with the two monitored buildings for which end use data were recorded).

Table 1. Office Building Electricity Savings Estimate

	1999 PG&E Commercial Building Survey Baseline kWh/ft²-yr	Estimated % Savings Based on Simulations (see Table 3)	Savings kWh/ft²-yr	Savings \$/ft²-yr*
Fans	1.5	57%	0.85	\$0.12
Cooling	4.5	14%	0.63	\$0.08
Total HVAC electricity	6.0		1.48 (25%)	\$0.20
Total Electricity	12.7		1.48 (12%)	\$0.20

*Assumes \$0.137/kWh, the average cost based on simulations using PG&E’s E-20S rate.

Table 2. Office Building Gas Savings Estimate

	1999 PG&E Commercial Building Survey Baseline kBtu/ft²-yr	Estimated % Savings Based on Simulations (see Table 3)	Savings kBtu/ft²-yr	Savings \$/ft²-yr
Heating	20.6	41%	8.46	\$0.07

*Assumes \$0.84/therm, the average cost based on simulations using PG&E’s GNR-1 gas rate.

The savings fractions for fan energy (57%), cooling energy (14%), and heating energy (41%) that are listed in Table 1 are based on simulations comparing standard practice to best practice for a 50,000 ft² office building. Details of these simulations are included in an appendix to the guideline. The efficiency measures providing the majority of savings are supply air pressure reset controls and sizing of VAV boxes to allow for 10% minimum flow.

Table 3. Simulation Results and End Use Savings Fractions Used in Table 1

		Standard Practice	Best Practice	Savings	Savings Fraction
San Francisco (Climate Zone 3)					
Cooling	(kWh/yr)	111,522	89,428	22,094	19.8%
Fan	(kWh/yr)	33,231	12,613	20,618	62.0%
Heating	(kBtu/yr)	456,000	237,368	218,632	47.9%
Sacramento (Climate Zone 12)					
Cooling	(kWh/yr)	131,788	120,889	10,899	8.3%
Fan	(kWh/yr)	38,158	18,432	19,726	51.7%
Heating	(kBtu/yr)	528,800	347,901	180,899	34.2%
Average of San Francisco and Sacramento					
Cooling	(kWh/yr)				14.1%
Fan	(kWh/yr)				56.9%
Heating	(kBtu/yr)				41.1%

STATEWIDE CONSTRUCTION FORECAST

It is estimated that 1,500,000 ft² of large office space will be constructed annually that follows the recommendations in the guideline. Table 4 lists the assumptions behind this estimate, including the fraction of large offices that have applicable system types and the “penetration rate” of the guidelines within that group.

Table 4. Floor Area Forecast

		Floor Area	Source
Large office 10-year construction forecast		309,000,000 ft ²	2001 CEC Commercial Building Electricity Forecast
Annual construction		30,900,000 ft ² /yr	Assumes steady construction rate.
Floor area with applicable VAV reheat systems (maximum market potential)	~50% =	15,450,000ft ² /yr	Rough estimate based on 1999 CBS data showing chilled water systems accounting for 56% of office cooling capacity.
Floor area designed according to guideline recommendations (estimated market penetration)	~10% =	1,545,000 ft ² /yr	Rough guess for likely market penetration
Annual construction forecast		1,500,000 ft²/yr	Rounded to nearest 100,000 ft ²

STATEWIDE ENERGY SAVINGS

Combining the estimates of energy savings per square foot from Table 1 and Table 2 with the floor area forecast from Table 4 leads to the statewide savings listed in Table 5.

Table 5. Statewide Savings Estimates

	Electricity	Gas	Utility Cost
First year savings	2,220 MWh/yr	126,900 therms/yr	\$405,000/yr
Annual savings in year 10	22,200 MWh/yr	1,269,000 therms/yr	\$4,050,000/yr
Cumulative savings years 1 through 10	1,221,000 MWh	69,795,000 therms	\$222,750,000